NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, DC 20594

SURVIVAL FACTORS GROUP CHAIRMAN'S ADDENDUM #1

February 7, 2014

I. ACCIDENT

Operator	:	Asiana Airlines
Airplane	:	Boeing 777-200ER [HL7742]
Location	:	San Francisco, CA
Date	:	July 6, 2013
Time	:	1128 Pacific daylight time (PDT)[1]
NTSB #	:	DCA13MA120

II. SURVIVAL FACTORS GROUP

Group Chairman	:	Jason T. Fedok National Transportation Safety Board Washington, DC
Member	:	Emily Gibson National Transportation Safety Board Washington, DC
Member	:	Peter Wentz National Transportation Safety Board Washington, DC
Member	:	Rob Hentges Air Cruisers Company Wall Township, NJ
Member	:	Ed Vienckowski Air Cruisers Company Wall Township, NJ
Member	:	Sung Ky Oh Asiana Airlines Seoul, Korea

[1] All times are reported in local time unless otherwise noted.

Member	:	Hee Chang Lee Asiana Airlines Seoul, Korea
Member	:	Bruce Wallace Boeing Seattle, WA

III. SUMMARY

On July 6, 2013 at 11:28 am Pacific daylight time, a Boeing 777, registration HL7742, operated by Asiana Airlines as flight 214, struck the seawall short of runway 28L at San Francisco International Airport. The airplane was destroyed by impact forces and fire. Three of the 291 passengers were fatally injured. The flight was a regularly scheduled passenger flight from Incheon International Airport, Seoul, Korea, and was operated under the provisions of *14 Code of Federal Regulations Part 129*. Visual meteorological conditions prevailed at the time of the accident.

IV. DETAILS OF THE TESTING

1.0 Test Plan Protocol and Setup

Members of the Survival Factors Group met at MGA Research Corporation in Manassas, VA on January 21-22, 2014. A test plan was developed in order to attempt to understand the forces needed to cause a 777 evacuation slide/raft to release from its packboard and cause component damage similar to what was discovered during the group's teardown of the units from the Asiana 214 accident. The testing was performed with fully packed 777 slide/raft packs mounted such that they were subjected to an inboard load, a downward load or a 45 degree, combined inboard/downward load.[2] The slide/raft pack consisted of a rigid packboard, a folded inflatable slide/raft with aluminum inflation aspirators, a compressed gas reservoir, and a survival kit. The components were contained on the packboard by a yellow lacing cover, also known as a valise. The compressed gas reservoir cylinder was nominally 1500 cubic inches in volume. For in-service units, the cylinders are charged with CO_2 and N_2 to a pressure of approximately 3000 psi. For safe conduct of these tests, the cylinders were not under pressure, but partially filled with water to simulate the weight of the gas. The weight of the added water equaled the appropriate weight of gas specified for each unit.

Air Cruisers provided seven slide/rafts for testing; however, only 6 were used. They consisted of a combination of door 1R, door 1L, and door 2L units due to limited availability of specimens from an identical door position. The total weight of the each test unit was slightly different due to minor differences in size and length. Boeing provided 777 mounting brackets identical to those on the accident airplane to mount the units to the test fixture. The dimensions

[2] Although not called for in the initial test plan, combined inboard/downward load tests were performed (with the agreement of all parties) in an effort to obtain additional information about the direction of load necessary to cause slide/raft pack release and replicate damage from the accident airplane.

of the units were approximately 37 inches wide by 28 inches tall by 15 inches deep. Individual part numbers, serial numbers and weights were recorded for each test. MGA engineers recorded both data, photos, and hi-speed video of each test and produced a report that can be found as attachment 1. Summaries of each test and any damage caused can be found below.

2.0 Testing Results

Acceleration Sled Test #1

Type of Test	Inboard Load		**Test Date**	January 21, 2014
Part Number	62771-101 (Door 1L)		**Unit Weight**	217.4 lbs
Serial Number	5002		**Effective Weight**[3]	193.9 lbs
Iteration	**Target g Load**	**Actual g Load**	**Damage**	**Time**
1st run	3.0g	3.2g	None	0905
2nd run	7.0g	5.1g	None	0926
3rd run	7.0g	7.0g	None	0935
4th run	9.0g	8.9g	None	0952
5th run	11.0g	10.8g	None	1009
6th run	13.0g	12.6g	None	1027
7th run	15.0g	14.8g	Yes	1044

The first test was conducted with the slide/raft pack positioned for an inboard load (photo 1). The test consisted of 7 accelerated sled runs. No damage was noted on the first six runs. The slide/raft pack released on the 7th run after 99ms at an acceleration of 14.4g. The unit was examined in detail. The aft aspirator strap released. High-speed video of the test indicated that the release shaft did not rotate prior to the separation of the aspirator strap (see attachment 2). Seven of the 8 release cable balls (photo 2) separated from their respective cables that they were swaged to which allowed the valise to partially open and the slide/raft pack to release. The pin shields were removed and no witness marks from the release cable balls were observed. The release mechanism was removed from the packboard in order to observe the release shaft and tang. Neither the tang nor the release shaft was damaged.

[3] The effective weight was defined as the weight of the components that exerted a load on the release mechanism during the tests. The packboard assembly, girt, and girt bar did not exert a load onto the release mechanism and therefore were subtracted from the unit weight.

Photo 1. Slide/raft pack positioned for inboard load

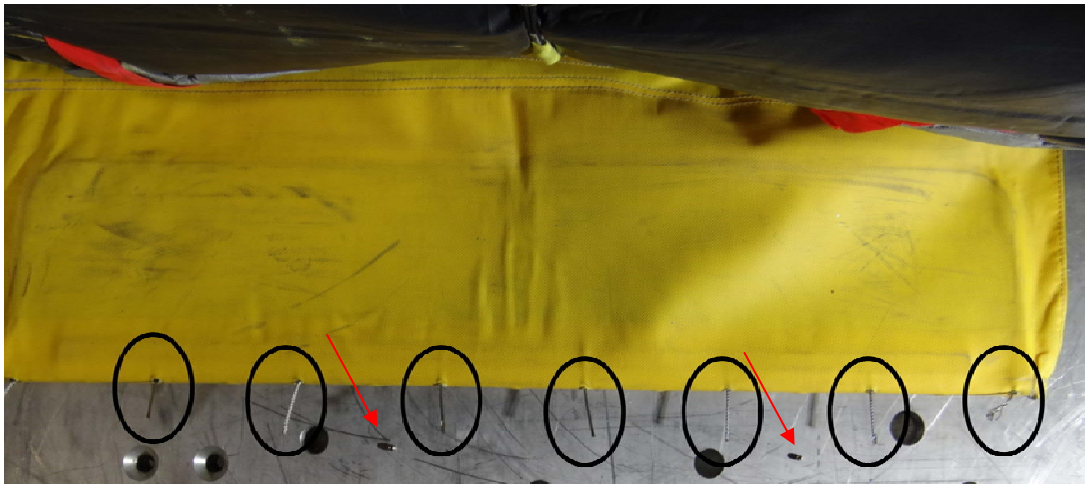
Photo 2. Seven damaged packboard release cables and two separated cable balls

Acceleration Sled Test #2

Type of Test	Inboard Load	**Test Date**	January 21, 2014
Part Number	62771-109 (Door 1L)	**Unit Weight**	219.9 lbs
Serial Number	0278	**Effective Weight**	196.4 lbs

Iteration	**Target g Load**	**Actual g Load**	**Damage**	**Time**
1st run	14.8g	15.0g	Yes	1135

The second test was conducted with the slide/raft pack positioned for an inboard load. The test consisted of 1 accelerated sled run and the slide/raft pack released after 86ms at an acceleration of 14.2g. The unit was examined in detail. Both aspirator straps had released. High-speed video of the test indicated that the release shaft did not rotate prior to the separation of the aspirator straps. High-speed video also showed that, after the release of the aspirator straps, the inflatable slide/raft came completely off the packboard and traveled inboard until the girt was taut. When braking was applied to the sled, the slide/raft rebounded and settled next to the packboard. It did not unfold. Seven of the 8 release cable balls separated from their respective cables that they were swaged to which allowed the valise to open and the slide/raft pack to release. The pin shields were removed and no witness marks from the release cable balls were observed. The release mechanism was removed from the packboard in order to observe the release shaft and tang. Neither the tang nor the release shaft was damaged. It was noted that the pulley mechanism inside the inflation valve had moved slightly and a safety pin could no longer be inserted into the valve (photo 3).

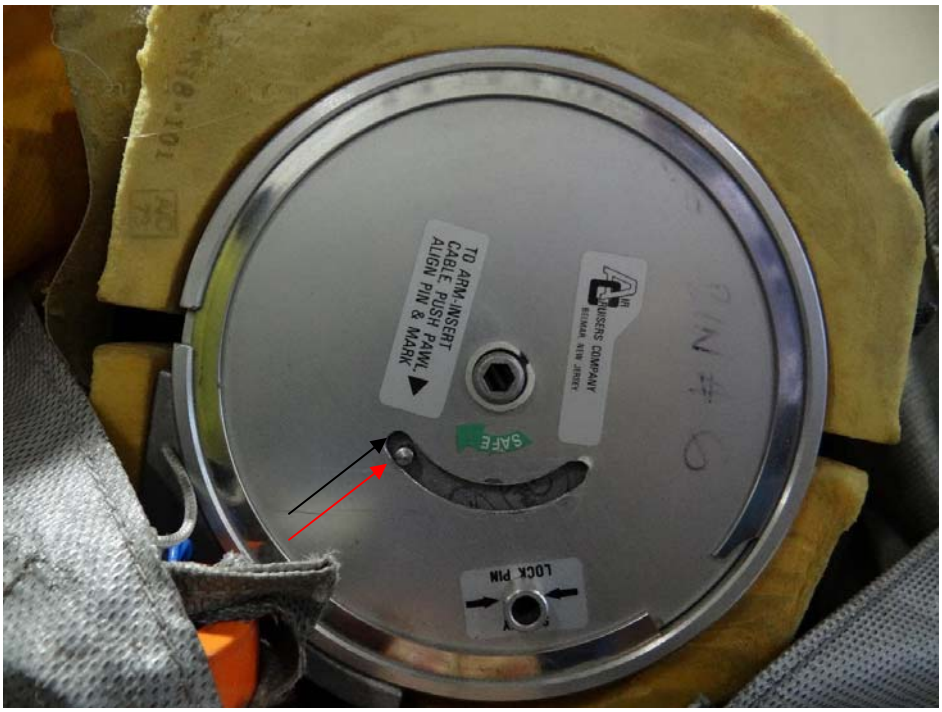

Photo 3. Slide/raft inflation valve (red arrow indicates final position of pulley indicator; black arrow shows the indicator's original position)

Acceleration Sled Test #3

Type of Test	Downward Load	**Test Date**	January 21, 2014
Part Number	62771-214 (Door 1R)	**Unit Weight**	222.9 lbs
Serial Number	0024	**Effective Weight**	199.4 lbs

Iteration	**Target g Load**	**Actual g Load**	**Damage**	**Time**
1st run	6.8g	7.2g	None	1318
2nd run	9.0g	9.0g	None	1339
3rd run	11.0g	10.9g	None	1400
4th run	13.0g	13.5g	Yes	1421

The third test was conducted with the slide/raft pack positioned for a downward load (photo 4). The test consisted of 4 accelerated sled runs. The slide/raft pack released on the 4th run after 94-96ms and 12.7-12.9g. The unit was examined in detail. Both aspirator straps had released. High-speed video of the test indicated that the release shaft rotated between 94-96ms. All 8 of the release cables released from the packboard and the release cable balls were intact. The release cables all had a noticeable curl. The pin shields were removed for examination and witness marks from the release cable balls (photo 5) were observed. The release mechanism was removed from the packboard to observe the release shaft and tang. The tang had torn the release shaft (photos 6 and 7) resulting in similar damage to that documented on the slide/rafts from doors 2R, 3R and 4R of the accident airplane.

Photo 4. Slide/raft pack positioned for downward load

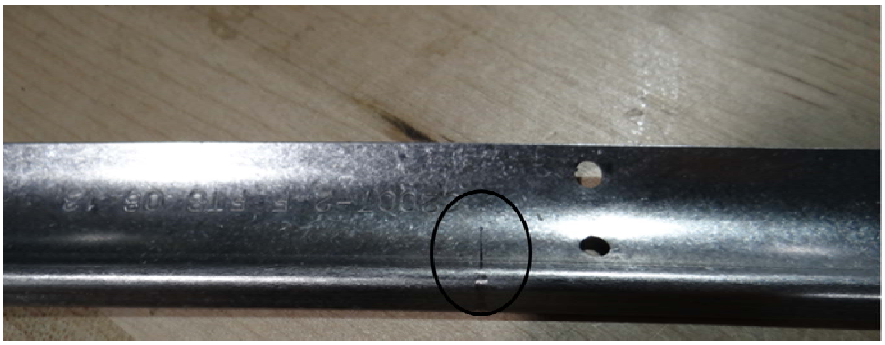

Photo 5. Pin shield witness mark

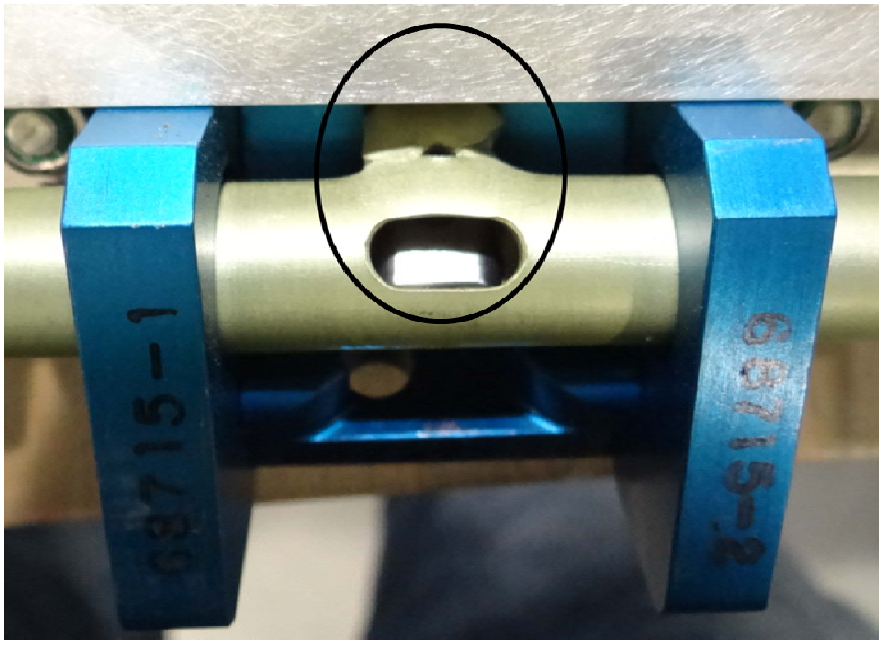

Photo 6. Packboard release mechanism with torn release shaft

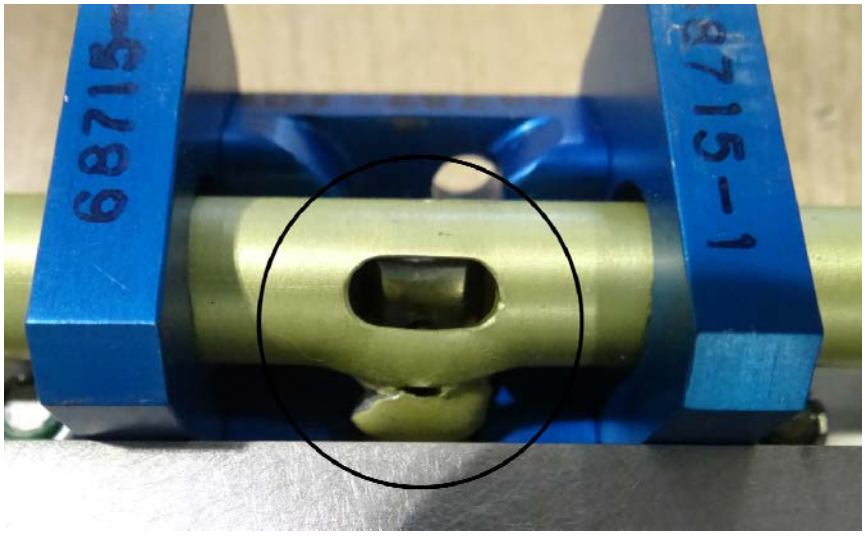

Photo 7. Packboard release mechanism with torn release shaft

Acceleration Sled Test #4

Type of Test	Downward Load	**Test Date**	January 21, 2014
Part Number	62771-113 (Door 1L)	**Unit Weight**	224.5 lbs
Serial Number	0032	**Effective Weight**	201.0 lbs

Iteration	**Target g Load**	**Actual g Load**	**Damage**	**Time**
1st run	13.0g	12.9g	None	1519
2nd run	14.0g	14.0g	Yes	1542

The fourth test was conducted with the slide/raft pack positioned for a downward load. The test consisted of 2 accelerated sled runs. The slide/raft pack released on the 2nd run after 101ms and 13.5g. The unit was examined in detail. The forward aspirator strap had released. High-speed video of the test indicated that the release shaft rotated at 101ms. All 8 of the release cables released from the packboard and the release cable balls were intact. The release cables all had a noticeable curl. The pin shields were removed for examination and witness marks from the release cable balls were observed. The release mechanism was removed from the packboard to observe the release shaft and tang. The tang had torn the release shaft resulting in similar damage to that documented on the slide/rafts from doors 2R, 3R and 4R of the accident airplane and acceleration sled test #3.

Acceleration Sled Test #5

Type of Test	45°/Combined Inboard & Downward Load	**Test Date**	January 22, 2014
Part Number	65342-217 (Door 2L)	**Unit Weight**	215.2 lbs
Serial Number	0003	**Effective Weight**	191.7 lbs

Iteration	**Target g Load**	**Actual g Load**	**Damage**	**Time**
1st run	10.0g	10.1g	None	1054
2nd run	12.0g	12.2g	None	1114
3rd run	14.0g	13.5g	Yes	1132

The fifth test was conducted with the slide/raft pack positioned for a 45 degree/combined inboard & downward load (photo 8). The test consisted of 3 accelerated sled runs. The slide/raft pack released on the 3rd run after 90ms and 12.4g. The unit was examined in detail. Both aspirator straps had released. High-speed video of the test indicated that the release shaft rotated at 101ms. All 8 of the release cables released from the packboard and the release cable balls were intact. The release cables all had a noticeable curl. The pin shields were removed for examination and witness marks from the release cable balls were observed. The release mechanism was removed from the packboard to observe the release shaft and tang. The tang had torn the release shaft resulting in similar damage to that documented on the slide/rafts from doors 2R, 3R and 4R of the accident airplane and acceleration sled tests #3 and #4.

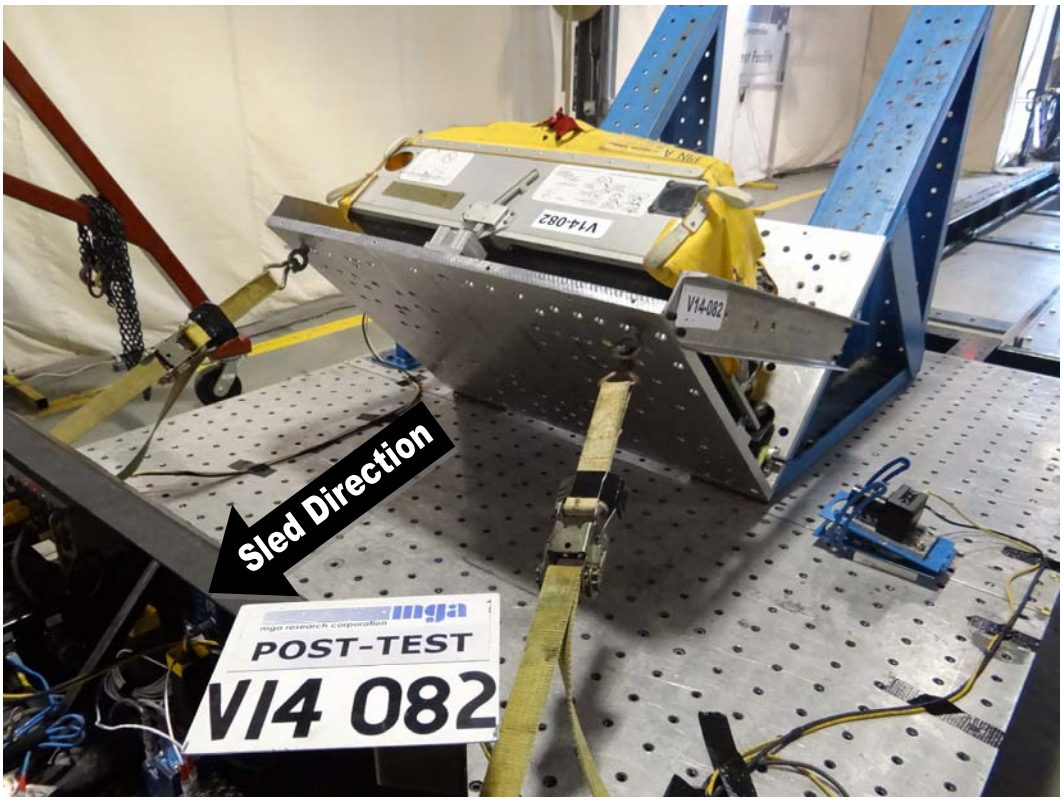

Photo 8. Slide/raft pack positioned for 45 degree combined inboard/downward load

Acceleration Sled Test #6

Type of Test	45°/Combined Inboard & Downward Load		**Test Date**	January 22, 2014
Part Number	62772-201 (Door 2L)		**Unit Weight**	211.0 lbs
Serial Number	0006		**Effective Weight**	187.5 lbs
Iteration	**Target g Load**	**Actual g Load**	**Damage**	**Time**
1st run	14.0g	13.2g	Yes	1230

The sixth test was conducted with the slide/raft pack positioned for a 45 degree/combined inboard & downward load. The test consisted of 1 accelerated sled run. The slide/raft pack released on the 1st run after 94-105ms and 12.9-12.6g.[4] The unit was examined in detail. Both aspirator straps had released. High-speed video of the test indicated that the release shaft began rotating at 94ms and continued until 105ms. All 8 of the release cables released from the packboard and the release cable balls were intact. The release cables all had a noticeable curl. The pin shields were removed for examination and witness marks from the release cable balls

[4] Examination of the high speed video footage indicated that the rotation of the shaft and release of the pack happened over a slightly longer period of time than previous tests. The rotation began at 94ms and 12.9 g and continued through the peak of 13.2g. The rotation continued until 105ms when the acceleration had decreased to 12.6g. See attachment 1 for graphs of the acceleration pulse for this test.

were observed. The release mechanism was removed from the packboard to observe the release shaft and tang. The tang had torn the release shaft resulting in similar damage to that documented on the slide/rafts from doors 2R, 3R and 4R of the accident airplane and acceleration sled tests #3 and #4, and #5.

Summary

Testing of all six units resulted in slide/raft release from the packboard. The following table provides a summary of the peak forces measured to release the slide/raft from the packboard for each test unit. Tests #1 and #2 (inboard load) resulted in the fracturing of 7 of 8 swaged release cable balls on the valise and did not replicate damage seen on the release shaft from doors 2R, 3R, and 4R of the accident airplane. Tests #3, #4, #5, and #6 (downward and 45° combined loads) resulted in similar curling of the release cables and damage to the release shafts that was documented on the slide/rafts from doors 2R, 3R, and 4R of the accident airplane.

Test Number	Orientation	Target G Level	Actual G Level	Time of Damage	G-Level at Time of Damage
1	Inboard	15	14.8	99	14.4
2	Inboard	15	15	86	14.2
3	Downward	13	13.5	94-96	12.7-12.9
4	Downward	14	14	101	13.5
5	45° Combined	14	13.5	90	12.4
6	45° Combined	14	13.2	94-105	12.9-12.6

3.0 Measurements of Slide/Raft Movement

In an effort to obtain a measurement of how far the slide/raft would have to move to initiate the inflation process after release from the packboard, a slide/raft pack was intentionally released from the valise cover and laid on the floor as if the top of the pack had fallen inboard. Measurements were then recorded of the distances between the girt bar and the center of the inflation valve and of the inflation cable itself. The distance between the girt bar and the center of the inflation valve measured 40.5 inches (photo 9). The length of the inflation cable from the girt grommet to its insertion point in the inflation valve measured 60.5 inches (photo 10).

The girt bar was then anchored to the floor and the slide/raft was manually pulled along the floor (horizontally) until the inflation cable released from the inflation valve. The same measurements were taken again in order to determine how far inboard a loose slide/raft pack

would have to travel before inflation occurred. The distance between the girt bar and the center of the inflation valve at the time of inflation cable release measured 47 inches, meaning that the pack traveled 6.5 inches prior to release. The length of the inflation cable from the girt grommet to its insertion point in the inflation valve measured 63.5 inches after inflation cable release.

Photo 9. Measurement from girt bar to center of closed inflation valve

Photo 10. Measurement of the inflation cable with valve in the closed position

Photo 11. Measurement of the inflation cable with valve in the half open position